RESEARCH HIGHLIGHT

May 2014 Technical Series 14-100

Urban Heat Island Mitigation Measures and Regulations in Montréal and Toronto

INTRODUCTION

The Heat Island Research Group of the Department of Geography at the Université du Québec à Montréal has studied mitigation measures and planning and regulatory tools Montréal and Toronto have to help reduce the number of heat islands.

The heat island phenomenon[1] has been increasing steadily around the world in the past 150 years. The causes are many and known, but we will focus mainly on the loss of vegetation-covered space, the mineralization of the territory, the physical properties of some covering materials, their wear, the densification of built-up space and the increase in impermeable surfaces. As a result, it is not unusual to find temperature differences of 10, 15 and even 20°C and over in the same city or town along distances of a few hundred metres.

The proliferation of heat islands is of some concern, because they affect the health of the public, especially seniors, young children and the underprivileged. We need only to think about the 70,000 deaths in Europe in 2003 or about the 800 fatalities in Chicago in 1995. These figures only take into account deaths relating to heat waves, but if air pollution is brought into the picture, the numbers spike dramatically.

Methodology

This project consisted of three steps:

1. Completion and analysis of the thermal pictures of Montréal and Toronto.
2. Inventory and selection of appropriate mitigation measures.
3. Review and summary of the planning and regulatory tools in Montréal and Toronto.

1. Thermal pictures

The surface thermal pictures of Montréal in the summer of 2011 and Toronto in the summer of 2010 were developed using Landsat 5 satellite images.[2] Heat maps of different scales were produced along with Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI) maps. A land-use analysis was also performed.

2. Inventory of mitigation measures

Various mitigation measures were identified based on a literature review and observations made in several cities. In addition, it was noted that, in order to reduce the presence of heat islands, it was preferable to combine mitigation measures rather than to opt for just one measure.

3. Planning and regulatory tools in Montréal and Toronto

An overview of planning and regulatory tools that could affect the problem of urban heat islands was prepared in the summer of 2010. The information was classified into three categories: indicative, incentive and normative.

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[1] Heat islands are defined as urbanized areas where summer temperatures are higher than in the immediate environment, with differences that, according to the authors, vary from 5 to 10°C.

[2] http://earthexplorer.usgs.gov/

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Research

Thermal picture of Montréal

The thermal analysis of the Montréal region was performed on three map scales: (1) the census metropolitan area (CMA); (2) Montréal Island; and (3) boroughs/cities. Farming areas and water bodies were excluded.

A mere 8% or 150 km² of the Montréal CMA was affected by heat islands (figure 1). This corresponds to what we had anticipated, given the vegetation-covered space of 50% that is described as "high" (figure 2).

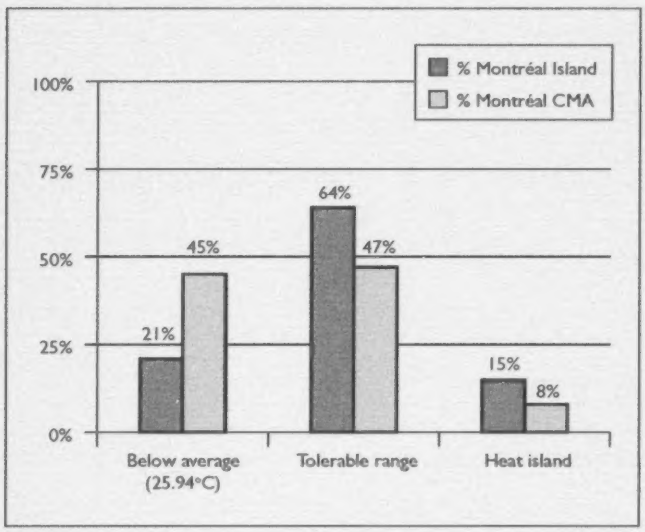

Figure 1 Proportion of heat islands in Montréal and in the Montréal CMA.

However, 70 km² of the 480 km² (i.e. ≈15%) of the Montréal Island are considered heat islands (>30.94°C). They are mainly found in the centre/south, north and east. The tolerable range (>25.94°C and <30.94°C) represents the majority (64%) of the Island (≈300 km²), and the coolest part (that is, below average) is located mainly on the west part of the island and accounts for 21% (≈100 km²). Given the increasing urbanization, the countryside character of the suburbs will continue to worsen from a thermal standpoint if development practices are not changed.

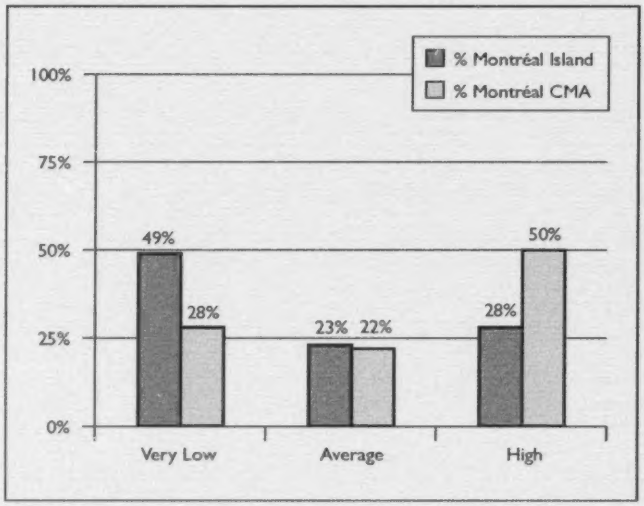

Figure 2 Proportion of vegetative biomass (NDVI) in Montréal and in the Montréal CMA.

With the focus at the borough level, for example on Plateau-Mont-Royal (figure 3), it can be seen that heat islands are highly concentrated in high-density residential areas and that nearby vegetation-covered spaces (Lafontaine Park and Mount Royal) have a beneficial effect.

When figures 1 and 2 are combined, it can be easily seen that the more highly vegetation-covered spaces have lower proportions of heat islands. The positive effects of shading, evapotranspiration and permeability are therefore detected by satellite images.

Thermal picture of Toronto

The approach taken to analyze the Toronto region was basically the same one that was used for Montréal. However, one must avoid comparing Montréal and Toronto from a thermal standpoint, as Lake Ontario has a substantial effect on Toronto's thermal situation. Furthermore, the presence of cirrus and cirrocumulus clouds on the Toronto satellite image affected the results to some degree.

About 53% (≈1,400 km²) of the Toronto CMA is under the average temperature of 26.22°C. As a result, only 4% (≈115 km²) of its territory (figure 4) is affected by heat islands.

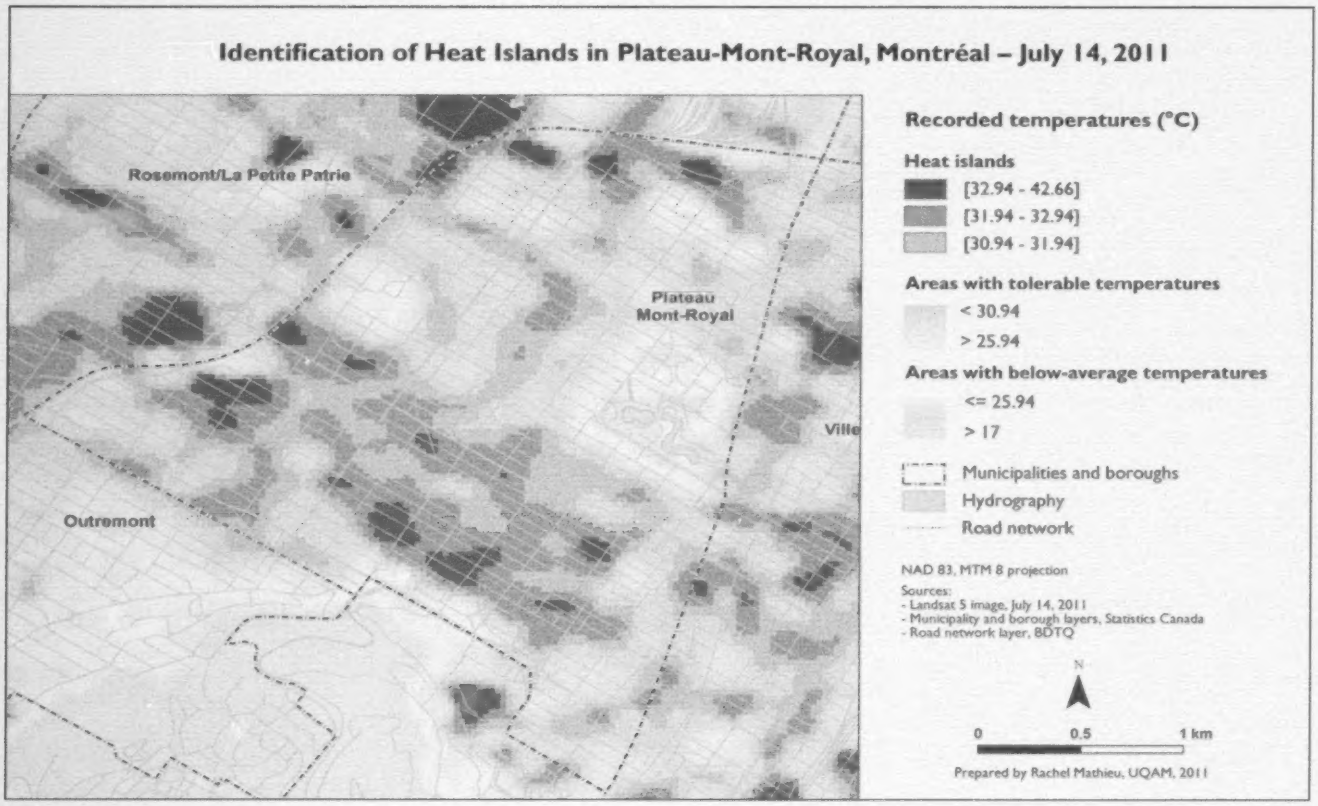

Figure 3 Thermal picture of the Montréal CMA on July 14, 2011 (Source: Landsat 5, band 6).

In the case of the city of Toronto, 74% of the area is in the tolerable range (>26.22°C and < 31.22°C) and 20% is below average (26.22°C). Only 37 km² or 6% of its area are covered by heat islands, mainly in the northeast (see example in figure 5, Humber Summit) and the northwest. Heat islands are also found in Mississauga, Brampton, Vaughan East, Markham Centre, Newmarket and Aurora.

Considering the reservations expressed about the low values on the Toronto heat map and the prevailing meteorological conditions when the image was taken, it was noted that the shoreline areas in Toronto, its downtown area and Etobicoke have a very low NDVI and their thermal performance is in the tolerable zone. Therefore, other parameters affect Toronto.

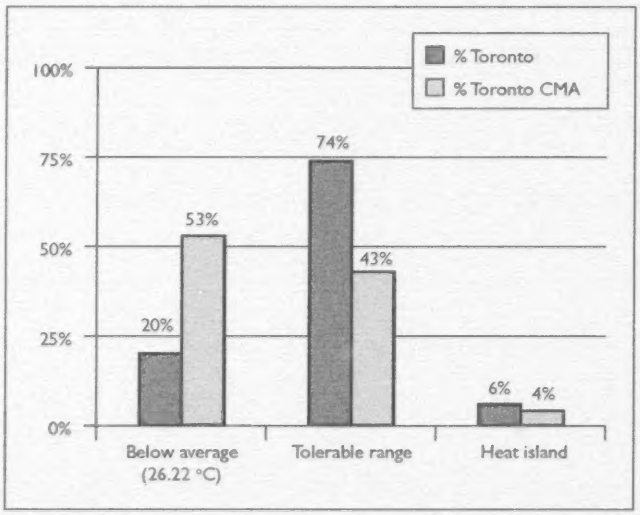

Figure 4 Proportion of heat islands in Toronto and in the Toronto CMA.

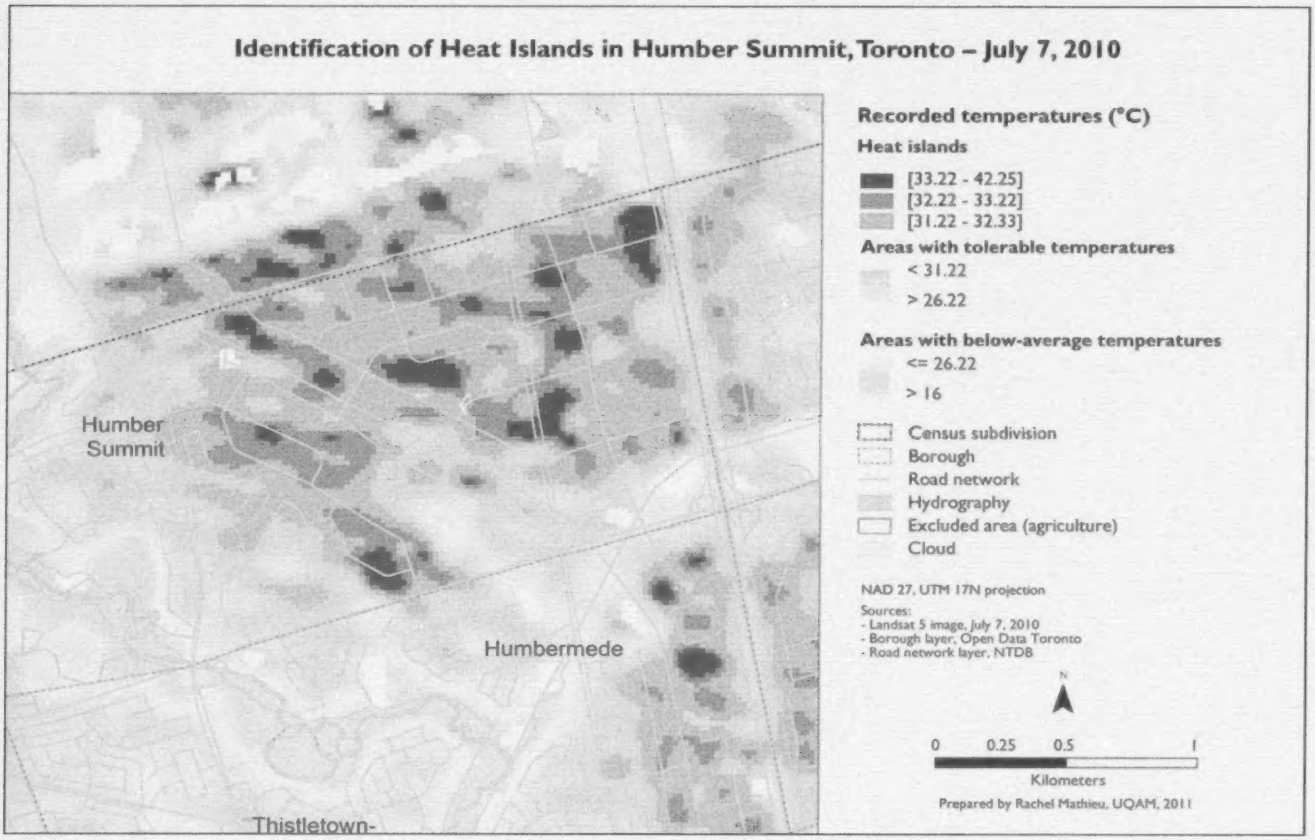

Figure 5 Thermal picture of the Humber Summit sector (Source: Landsat 5, band 6).

More than one quarter of the Toronto CMA has little vegetation (figure 6). Meanwhile, 54% has heavy vegetative cover.

A little more than 45% of the city of Toronto is qualified as having very little vegetation, which is similar to the proportion in Montréal (49%).

Municipal planning and regulatory tools

Municipal governments can use several planning and regulatory tools to reduce heat islands on their territory. The normative urban planning and land-use planning framework in Toronto and Montréal were studied to identify all of the measures likely to lower temperatures in the built-up area.

Three levels of planning are generally followed. The first level, indicative planning, involves a series of recommendations and guidelines, which do not entail mandatory compliance or any form of accommodation. Incentive planning, at level two, involves offering grants or various forms of relief to encourage stakeholders to comply with the proposed measures. Finally, the third level, normative planning, consists of a series of urban planning bylaws or other such mechanisms that all development or new construction must be in compliance with.

Montréal

In the general normative framework of metropolitan Montréal, no guideline pertains directly to heat islands, but several sustainable development, environmental development and greening policies and programs do incorporate specific measures that have a direct effect on the phenomenon in question. In addition to elements relating to the reduction of motor vehicle transportation, the development of green spaces and the accommodation of active transportation, the framework does address planning for landscape plantings along several arteries and a willingness to reduce mineralized and/or impermeable surfaces. Parking spaces are particularly covered by these measures, as are the roofs of large buildings (commercial, institutional or industrial) where provision is made for the establishment of green or white roofs. Some normative measures are laid out in greater detail in some boroughs (Saint-Laurent and Rosemont-La Petite-Patrie).

Toronto

The normative framework of the Toronto region is far more explicit than Montréal's in terms of heat islands. All of the regulations dealing with the development of major arteries and the natural environment identify several mitigation measures that are either indicative or normative in nature (figure 7). Specific programs *(Toronto Green Standard, Design Guidelines for Greening Surface Parking Lots, Green Roof Bylaw, Eco-Roof Incentive Program)* are dedicated to reducing temperatures of parking spaces and to greening roofs. The compulsory measures pertaining to both types of space are highly detailed and have already been incorporated into the municipality's urban planning bylaws.

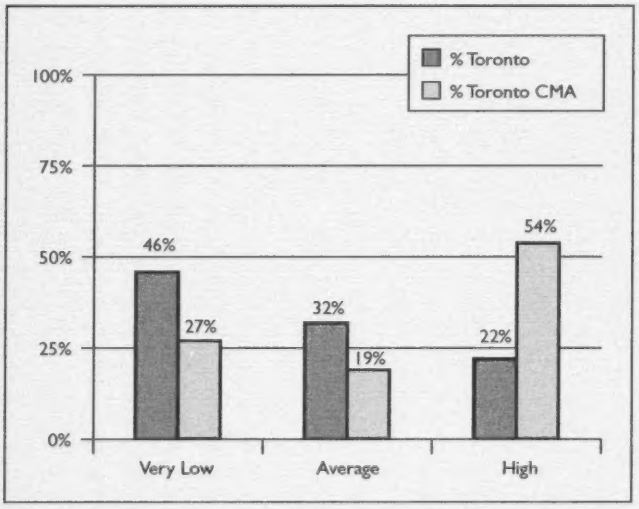

Figure 6 Proportion of vegetative biomass (NDVI) in Toronto and in the Toronto CMA.

Figure 7 Toronto: Use of climbing plants on the facades of old industrial buildings converted into dwellings; June 2011.

Proposed mitigation measures

In order to combat heat islands effectively, the simultaneous introduction of various mitigation measures is the more efficient approach. Generally speaking, it costs less to adopt measures at the start of a project rather than when it is completed. Moreover, further to the analyses performed, specific attention will have to be paid to commercial and industrial sectors.

Once implemented, the measures produce numerous benefits such as lower surface and felt temperatures, reduced mortality, better quality of life, less smog, smaller temperature variances, longer useful life of materials, energy savings, higher property values and fewer floods.

Reduce parking spaces

- Give priority to multi-storey parking garages (with green roofs) and underground garages.
- Increase shading by planting vegetation.
- Establish green strips.
- Reduce parking surfaces and increase bicycle parking areas.

Change roofs and facades

- Introduce cool roofs and cool facades by using materials with a high solar reflectance index (SRI).
- Maintain and clean roofs on a regular basis.
- Lean toward green roofs.
- Plant roof gardens.
- Go with vegetation on the facades (facing south and west).
- Plant trees with deciduous leaves.

Reconsider some architectural and urban design and landscaping practices

- Avoid constructing buildings in enclaves and in topographic depressions.
- Vary the height of buildings.
- Maintain the height/width ratio at less than 1.
- Encourage strong ventilation in the districts with the highest densities.
- Consider orientation both in the construction of buildings and the planting of vegetation.

Increase permeability, surface water catchment and water bodies

- Incorporate water bodies into new projects.
- Arrange for surface water catchment for watering vegetation.
- Reduce the width of roadways.
- Promote geothermal energy.

Prioritize vegetative covers

- Increase vegetation-covered surfaces using plants that can withstand local conditions.
- Eliminate artificial vegetation-covered surfaces.
- Plant trees with deciduous leaves along road arteries.
- Conserve and increase the number of parks.
- Conserve and increase public shoreline spaces.
- Develop regulations to conserve existing green spaces.

Select covering materials carefully

- Promote the use of cool pavements.
- Review covering surfaces on roads.
- Reconsider highly mineralized tourist areas.
- Avoid using synthetic materials (for example, artificial turf) to the detriment of natural materials.

CONCLUSION

Our urban environments are thermally deteriorating, but various positive approaches are nonetheless being taken to head off this phenomenon. Toronto has passed comprehensive bylaws to combat heat islands, while several local initiatives have been noted in Montréal.

Mineralization is the main culprit in the degradation, but making smart choices, before projects are undertaken, can help better prevent heat islands and their effects on health. Conserving existing green spaces, using more appropraite materials, opting for designs that address both the issues and their impacts, reducing impermeable surfaces and developing a better public transit policy should reduce the presence of urban heat islands.

An impressive number of innovative initiatives have been developed in several large American and European cities. The initiatives do exist, and positive results have been demonstrated. Now the time has come to take the necessary policy and regulatory measures.

Implications for the Canadian housing industry

The rapid growth of Canada's major urban centres has had significant impacts on the quality of our living surroundings and on the environment in general. With ever-increasing mineralization of the built-up area and the exponential growth of motor vehicle transportation, the authorities responsible for urban planning and land-use planning must make adjustments and take measures to mitigate the harmful effects of urbanization. Various greening initiatives have always contributed to such efforts, and several innovations are becoming widespread around the world. We are also seeing innovations in the types of materials used and in the management of urban morphology and the multiplying effects of some actions in space, for the purpose of opening up the urban space and calibrating its growth more effectively from a sustainable, ecological and responsible development perspective.

For more information, please refer to the *Design Guide for Urban Heat Island Mitigation Measures* **Summary Report** or **Complete Report**.

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Printed in Canada
Produced by CMHC 08-05-14

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